

Alate gyne of the ant *Dolichoderus quadripunctatus* (L.) (Hymenoptera, Formicidae) follows foraging trail to aphids

Wojciech Czechowski¹, Gema Trigos-Peral¹, István Maák¹, Kari Vepsäläinen²

¹ Museum and Institute of Zoology, Polish Academy of Sciences, Wilcza St 64, 00-679 Warszawa, Poland

² Organismal and Evolutionary Biology Research Programme, University of Helsinki, PO Box 65, 00014 Helsinki, Finland

Corresponding author: Wojciech Czechowski (wcz@miiz.waw.pl)

Academic editor: Petr Klimeš | Received 20 May 2019 | Accepted 26 July 2019 | Published 30 August 2019

<http://zoobank.org/89E633AC-5E30-469F-B1A4-2F78BDEEF047>

Citation: Czechowski W, Trigos-Peral G, Maák I, Vepsäläinen K (2019) Alate gyne of the ant *Dolichoderus quadripunctatus* (L.) (Hymenoptera, Formicidae) follows foraging trail to aphids. Journal of Hymenoptera Research 71: 241–248. <https://doi.org/10.3897/jhr.71.36286>

Abstract

The first observation of alate gyne of *Dolichoderus quadripunctatus* (L.) visiting aphids is described. A gyne walked along a foraging trail to the aphid *Panaphis juglandis* Goeze colony where it imbibed honeydew excreted on the leaf by the aphids, after which it returned to the trail. This recurred during two more days, always a single alate gyne at a time; hence the total number of gynes, one or more, remained open. The phenomenon, hitherto practically unknown in ants, is presented against the background of the biology of the species and discussed in the context of specific environmental circumstances and the colony dynamics.

Keywords

Ants, aphids, behavioural plasticity, colony dynamics, gyne foraging, life history, *Panaphis juglandis*

Introduction

In ants and other social insects, the basic division of tasks is such that workers take care of the colony tasks, whereas queens reproduce (Hölldobler and Wilson 1990). The variation around this basic theme is, however, large, depending on the species and specific circumstances. For example, workers of many species may produce male offspring (Bourke 1988). On the other hand queens may forage (see Discussion). Until now,

the published records on foraging gynes or queens have been on dealate individuals, in which plausible explanations are easily found, whereas observations on foraging alates seem to be lacking.

Here, we report our observations on this previously practically unknown behaviour, foraging of one or more alate ant gynes [though see Discussion on the microgynes of *Manica rubida* (Latr.)], and discuss it in a wider context of the biology and life history of the species in question, *Dolichoderus quadripunctatus* (L.).

The observations

Observations were made in the area with sparse single-family housing in Brwinów (52°08'N, 20°43'E) near Warsaw, Poland. The site of observation was in a garden growing, among others, a few common walnut trees (*Juglans regia* L.) next to a detached house with old wooden elements (elevation, pillars, balustrades) (Fig. 1). Nests of *D. quadripunctatus* were located in the walnut trees and in the wooden elements of the building and fences; the ants foraged mainly in the crowns of the trees. Observations were conducted irregularly in the years 2010–2019, with the most interesting finding recorded in July 2017.

At the beginning of July 2017, a colony of nymphs of the large walnut aphid *Panaphis juglandis* Goeze appeared on a leaf of a young walnut tree, on its upper surface, at a height of 1.1 m above the ground. On July 7, the aphids were discovered by *D. quadripunctatus* foragers from a nest in a wooden terrace pillar at a height of c. 4.5 m above the ground (Fig. 1). The ants formed a regular foraging trail from their nest to the aphids. The intricate trail measured at least 13 m (the ants came out of the crack of the pillar, but the location of the nest was unknown). The traffic intensity was low: one to two individuals per minute in each direction. During the day, depending on the weather, the aphids were accompanied by a few to nearly 30 workers. In the following days, two smaller *P. juglandis* colonies appeared on other leaves of the same tree. They were also visited by *D. quadripunctatus*, although with lower activity.

On July 16, an alate *D. quadripunctatus* gyne appeared at the aphids (Fig. 2). Like the workers, it licked the honeydew from the leaf surface in the immediate vicinity of the aphids. It did it less efficiently than the workers, with long breaks, thus spending much more time on the leaf than the workers. After about 15 minutes, the gyne left the leaf, following the foraging trail towards the nest. During occasional observations in the following days, the presence of a single alate gyne among foraging workers was recorded twice at the same aphid colony. Each time the gyne was seen at the aphids during sunny warm weather, when the foraging activity of the *D. quadripunctatus* workers was highest.

At the end of July, a ladybird (*Adalia bipunctata* L.) appeared at the aphid colony. Within three days, without being counteracted by the ants, it ate all the aphids. In the following days also the other two colonies of *P. juglandis* were consumed, which put an end to the observations. The lack of defense of the food resources by *D. quadripunctatus*

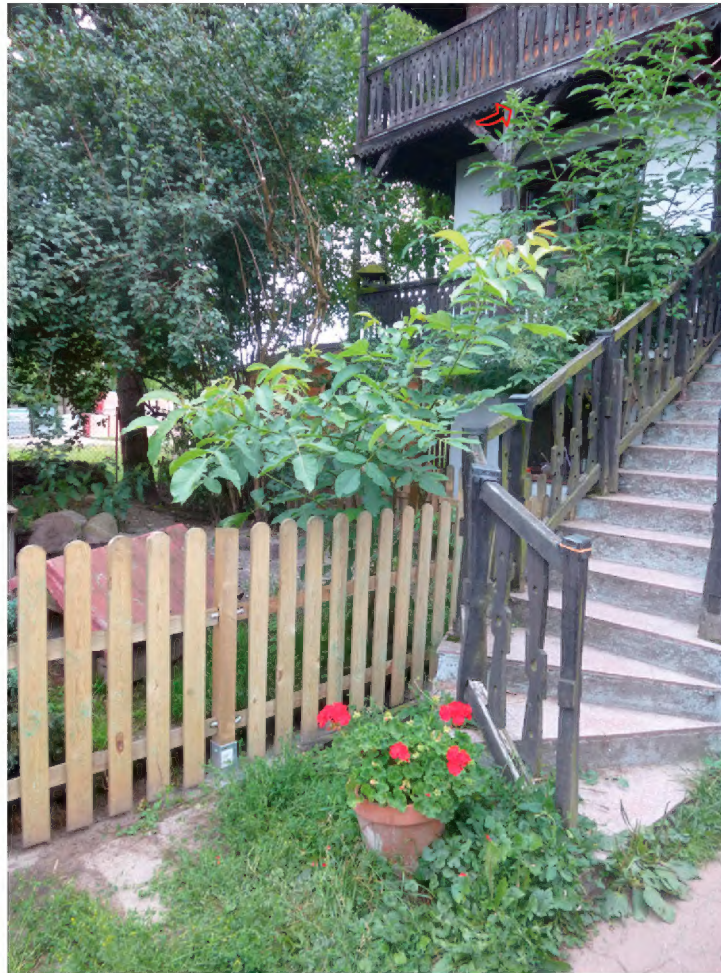


Figure 1. Site of observation; in the foreground, the young walnut with aphids, above (along the stairs), the black elder bush. The location of the *D. quadripunctatus* nest is indicated with an arrow. Photo taken on 16.07.2017 (Tadeusz Berliński).



Figure 2. Aphids *Panaphis juglandis* visited by workers and alate gyne of *D. quadripunctatus*. Photo taken on 16.07.2017 (Tadeusz Berliński).

was also revealed by multiple observations of the syrphid fly which, not disturbed by ants, licked the honeydew in the immediate vicinity of them. Concurrently, elsewhere in the garden, *D. quadripunctatus* foragers used experimentally placed baits with diluted honey, but withdrew on the appearance of *Lasius niger* (L.) workers.

The foraging trail along which the alate gynes walked to the aphid colony on the young walnut, led, inter alia, through the trunk and twigs of a black elder (*Sambucus nigra* L.) shrub. The critical point of the route was the passage from the elder leaf to the handrail of the stairs (Fig. 1). When even a slight wind made the leaves touch the railing intermittently, the ants managed to overcome the gap.

Discussion

Foraging of inseminated dealate young gynes is not uncommon in ants. It is the norm in a lot of species which found new colonies semi-claustrally (e.g. Fridman and Avital 1983; Johnson 1996; Brown 1999; Brown and Bonhoeffer 2003; Peeters and Molet 2009), although the evolutionarily derived feature, claustral colony founding (where queens do not leave the nest), is the common mode in extant ants (Hölldobler and Wilson 1990). Species with semi-claustral colony founding with foraging dealate queens are known especially in the tropics and subtropics (e.g. Anderson et al. 2006, Brown 1999, Johnson 1996, 2002, Lenoir and Dejean 1994). In temperate regions, the dealate, mated fundatrices (founding queens) of *Manica rubida* and *Myrmica* species leave their nest to forage still after the first overwintering (Le Masne and Bonavita 1969; Elmes 1982; Lenoir et al. 2010).

In Dolichoderinae, foraging of queens is scarcely documented. It was only recently documented within the genus *Technomyrmex* Mayr which includes many tramp species; ergatoid (worker-like) queens of *T. vitiensis* Mann were foraging outside the nest with workers (Väänänen et al. 2018). In the light of this scarceness, the foraging of the alate *Dolichoderus quadripunctatus* gyne(s) is peculiar – overall, such foraging of alate ant gynes seems unusual (or at least unreported) in nature. The mating status and possible hibernation of the *D. quadripunctatus* gyne(s) observed by us remain unknown. A comparable case concerns the poorly known microgyne caste in *Manica rubida*, whose status also remains unrecognised. In the colony, the alates seem to fulfil the task of workers by foraging outside the nests (Lenoir et al. 2010).

In the following, we will discuss this new finding in *D. quadripunctatus* in the light of the biology and life history of the species. It is a Euro-West-Siberian xerothermophilic oligotope of warm bright forests, also found in old orchards, gardens and parks. It is a dendrobiontic species which forages almost exclusively on trees (mainly in canopies) and is well adapted to move around the leaves (Seifert 2008). The agility of the species to move in an unstable environment and ability to find alternative routes (including a few metres long nylon washing lines) was also evident in our long-standing observations.

The species avoids encounters with heterospecific ants (Torossian 1979; Czechowski et al. 2012; Seifert 2018), although a mere high number of workers may displace

other species to the periphery of its foraging area (Stukalyuk 2018). Our own observations on the non-aggressive behaviour of the *D. quadripunctatus* workers against the predatory ladybird beetle which consumed the aphids, and against the honeydew-consuming syrphid fly, may be interpreted such that the honeydew source was a relatively marginal one in the resource spectrum of this ant, which is basically a predatory species (Seifert 2018). Our *D. quadripunctatus* gyne(s) and workers were observed only to lick honeydew from the leaves, not to milk the aphids as it is the norm in true trophobiosis where the ants in return offer protection to the aphids (Hölldobler and Wilson 1990). Consumption of dropped honeydew without trophobiosis seems to be the usual way of aphid attendance for *D. quadripunctatus* (Seifert 2008) as for many other arthropods which feed on excrements of aphids on the leaves (Ulyshen 2011).

It is noteworthy that Stukalyuk (2018), while working on the supercolony of *D. quadripunctatus*, never observed alate gynes on the foraging trails, even though he saw them outside the nests (pers. comm. to WCz). This indicates that some specific circumstances may trigger the visits of *D. quadripunctatus* alate gynes to extra-nidal food sources. Here, we suggest two, not mutually excluding, explanations for this seemingly rare behaviour – remembering that seeming rarity is not synonymous with insignificance.

An evident first reason for the alate gyne(s) to leave the nest and follow worker trails to aphid colonies is an acute shortage of food in the nest. Indeed, in Poland the spring of 2017 was late and cool, and the summer generally rainy and unfavourable for insects, when alate gynes of *D. quadripunctatus* were observed at the aphids. The supposition that hunger drives alate gynes to forage is justified in light of the observation of Torosian (1968), who stated that the workers do not display special care for young gynes gathered together in queenless auxiliary nests from their emerging to mating time.

The impact of evident food shortage on the behaviour of ants, probably caused by an exceptionally dry summer, was reported by Vepsäläinen and Czechowski (2014). *Myrmica rugulosa* Nyl., a submissive species at the bottom of the ant competition hierarchy, temporarily took over groups of the aphid *Stomaphis quercus* (L.), which is obligately associated with the highest-level territorial ant species *Lasius fuliginosus* (Latr.). This unique intrusion lasted at least two weeks, during which *M. rugulosa* workers successfully brought honeydew milked from the *S. quercus* back to their nest(s). As in many other rare observations, one chooses the best explanation on indirect evidence. In this case, because the drought affected severely the herbs which harbour aphids normally used by *M. rugulosa*, the ants probably were forced to search for supplementary food. Here, the successful change of behaviour probably helped the colony to survive the drought period. As comes to the foraging of the alate gynes of *D. quadripunctatus*, the primary benefit was at the individual level.

To see how the foraging of alate gynes could contribute to the colony dynamics, an introduction to the social structure of a *D. quadripunctatus* colony is at place. Typically, it is monogynous polydomy with one main queenright nest and a few branch nests inhabited by workers with possible offspring. This structure is caused by the small size of individual nest spaces which most often can harbour maximally several tens of individuals; the entire colony usually consists of several hundred, rarely over 1000 adults

(Torossian 1960, 1967a; Seifert 2018). The scattered nest loci of the colony enable the species the following specific life-history features: (1) males arise only from eggs laid by workers; (2) worker oviposition is possible only away from the queen; (3) larvae can develop to gynes only without contact with the queen; (4) insemination of gynes frequently takes place inside or close to the nest; (5) to initiate a colony, the gyne needs to be adopted by queenless workers (Torossian 1967b, 1968, 1974; Seifert 2018).

Direct observations on how a gyne is able to find a queenless workforce and start a colony are lacking. It has been suggested that a group of workers may take the gyne to a queenless outpost nest (Torossian 1974). We suggest here an additional possibility, where gynes which visit aphid colonies might serendipitously take a trail back to a queenless nest and be accepted by its workers. The potential for success of such gyne behaviour could be highest in large supercolonies – like the one studied by Stukalyuk (2018) – where foraging trails of a high number of nests merge on a tree trunk, lead up to the crown, to spread there to a number of food sources (S. Stukalyuk, pers. comm. to WCz).

If our above suggestion has any value in the colony dynamics of *D. quadripunctatus*, the question remains, why alate gynes seem to be only very occasional visitors at aphid colonies. One evident reason is that the yearly number of gynes produced by a colony is low (Torossian 1974) and secondly, that the species is an arboreal ant which has usually most of its nests high up in the tree crowns, and which only exceptionally forages in the lower layers of vegetation (Seifert 2018). Simply, observations on what goes on in the main space of the colonies are needed in order to test our suggestion.

Acknowledgements

We thank the editor Petr Klimeš and two reviewers, whose comments helped to improve the article.

References

- Anderson KE, Keyl AC, Pollock GB (2006) Mating flight, metrosis, and semi-claustrality in the seed-harvester ant *Pogonomyrmex salinus* (Hymenoptera, Formicidae). *Insectes Sociaux* 53: 92–96. <https://doi.org/10.1007/s00040-005-0840-y>
- Bourke AFG (1988) Worker reproduction in the higher eusocial Hymenoptera. *The Quarterly Review of Biology* 63: 291–311. <https://doi.org/10.1086/415930>
- Brown MJF (1999) Semi-claustral founding and worker behaviour in gynes of *Messor andrei*. *Insectes Sociaux* 46: 194–195. <https://doi.org/10.1007/s000400050133>
- Brown MJF, Bonhoeffer S (2003) On the evolution of claustral colony founding in ants. *Evolutionary Ecology Research* 5: 305–313.
- Czechowski W, Radchenko A, Czechowska W, Vepsäläinen K (2012) The ants of Poland with reference to the myrmecofauna of Europe. *Fauna Poloniae n.s.* 4. Natura optima dux Foundation, Warszawa.

- Elmes GW (1982) The phenology of five species of *Myrmica* (Hym. Formicidae) from South Dorset, England. *Insectes Sociaux* 29: 548–559. <https://doi.org/10.1007/BF02224224>
- Fridman S, Avital E (1983) Foraging by queens of *Cataglyphis bicolor nigra* (Hymenoptera: Formicidae): an unusual phenomenon among the Formicidae. *Israel Journal of Zoology* 32: 229–230.
- Hölldobler B, Wilson EO (1990) The ants. Harvard University Press, Cambridge, MA. <https://doi.org/10.1007/978-3-662-10306-7>
- Johnson RA (1996) Capital and income breeding and the evolution of colony founding strategies in ants. *Insectes Sociaux* 53: 316–322. <https://doi.org/10.1007/s00040-006-0874-9>
- Johnson RA (2002) Semi-claustral colony founding in the seed-harvester ant *Pogonomyrmex californicus*: a comparative analysis of colony founding strategies. *Oecologia* 132: 60–67. <https://doi.org/10.1007/s00442-002-0960-2>
- Le Masne G, Bonavita A (1969) La fondation des sociétés selon un type archaïque par une fourmi appartenant à une sous famille évoluée. *Comptes Rendus des Séances de l'Académie des Sciences*, ser. D 269: 2373–2376.
- Lenoir A, Dejean A (1994) Semi-claustral colony foundation in the formicinae ants of the genus *Polyrhachis* (Hymenoptera: Formicidae). *Insectes Sociaux* 41: 225–234. <https://doi.org/10.1007/BF01242293>
- Lenoir A, Devers S, Marchand P, Bressac C, Savolainen R (2010) Microgynous queens in the Palearctic ant, *Manica rubida*: dispersal morphs or social parasites? *Journal of Insect Science* 10: article 17. <https://doi.org/10.1673/031.010.1701>
- Peeters C, Molet M (2009) Colonial reproduction and life histories. In: Lach L, Parr C, Abbott K (Eds) *Ant ecology*. Oxford University Press, Oxford, 161–178. <https://doi.org/10.1093/acprof:oso/9780199544639.003.0009>
- Seifert B (2008) The ants of Central European tree canopies (Hymenoptera: Formicidae) – an underestimated population? In: Floren A, Schmidl J (Eds) *Canopy arthropod research in Europe Bioform Entomology & Equipment*, Nuremberg: 157–173.
- Seifert B (2018) *The ants of Central and North Europe*. Iutra Verlags- und Vertriebsgesellschaft, Tauer.
- Stukalyuk S (2018) Supercolony of *Dolichoderus quadripunctatus* Linnaeus (Hymenoptera, Formicidae). *Biology Bulletin Reviews* 8: 449–462. <https://doi.org/10.1134/S2079086418050092>
- Torossian C (1960) La biologie de la fourmi *Dolichoderus quadripunctatus* (Hyménoptère – Formicoidea – Dolichoderidae). *Insectes Sociaux* 7: 383–393. <https://doi.org/10.1007/BF02225776>
- Torossian C (1967a) Recherches sur la biologie et l'éthologie de *Dolichoderus quadripunctatus* (L.) Hym. Formicoidea Dolichoderidae. I. Étude des populations dans leur milieu naturel. *Insectes Sociaux* 14: 105–121. <https://doi.org/10.1007/BF02223262>
- Torossian C (1967b) Rôle des reines sur la formation et l'apparition des sexués femelles dans les sociétés de la fourmi *Dolichoderus quadripunctatus* (Hym. Form. Dolichoderidae). *Comptes Rendus de la Société de Biologie* 161: 1455–1458.
- Torossian C (1968) Recherches sur la biologie et l'éthologie de *Dolichoderus quadripunctatus* (L.) (Hym. Form. Dolichoderidae). VIII. Mode de reproduction et cycle biologique des colonies. *Insectes Sociaux* 15: 375–387. <https://doi.org/10.1007/BF02223634>

- Torossian C (1974) Polymorphismus und Kastendifferenzierung bei Dolichoderiden. In: Schmidt GH (Ed.) Sozialpolymorphismus bei Insecten. Wissenschaftliche Verlagsgesellschaft MbH, Stuttgart, 862–884.
- Torossian C (1979) Importance quantitative des oeufs abortifs d'ouvrières dans le bilan trophique de la colonie de la fourmi *Dolichoderus quadripunctatus*. Insectes Sociaux 26: 295–299. <https://doi.org/10.1007/BF02223549>
- Ulyshen MD (2011) Arthropod vertical stratification in temperate deciduous forests: implications for conservation-oriented management. Forest Ecology and Management 261: 1479–1489. <https://doi.org/10.1016/j.foreco.2011.01.033>
- Väänänen S, Vepsäläinen K, Vepsäläinen V (2018) *Technomyrmex vitiensis* Mann, 1921 (Hymenoptera, Formicidae, Dolichoderinae), a new exotic tramp ant in Finland. Sahlbergia 24.1: 14–19.
- Vepsäläinen K, Czechowski W (2014) Against the odds of the ant competition hierarchy: submissive *Myrmica rugulosa* block access of the dominant *Lasius fuliginosus* to its aphids. Insectes Sociaux 61: 89–93. <https://doi.org/10.1007/s00040-013-0332-4>